

Neighborhood Context and Infant Birthweight Among Recent Immigrant Mothers: A Multilevel Analysis

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Socioeconomic disparities in birth outcomes are well documented,^{1–3} even in countries with universal access to health care,^{4,5} such as Canada. An increasing body of literature, including several multilevel studies, suggests that context affects birth outcomes, particularly neighborhood influences in predominantly urban areas.^{6–16} Little is known, however, about neighborhood influences among immigrants.^{15,17–19}

There are theoretical and practical reasons to explore this issue. It has been suggested that exposure to neighborhoods may take some time to affect human health.²⁰ Even if neighborhood influences are detected among the offspring of recent immigrant women exposed to neighborhoods during their entire pregnancy, a life-course perspective suggests that early life experiences and premigration exposures may still affect birth outcomes of migrants in the new country.^{19,21} The maternal country of origin thus constitutes another relevant context to be considered when analyzing differences in birthweight among recent immigrants, because substantial differences in birthweight have been reported by geographical region and nativity status.^{22–24} It is important to clarify the role of the pre- and postmigration exposures, because the proportion of live births to immigrant women has been showing an upward trend during recent decades in several industrialized countries.^{24–27}

We compared the influence of the residential environment at the time of delivery with that of the maternal country of origin on birthweight and the proportion of low birthweights among infants born to women who recently immigrated to Canada and settled in Ontario census metropolitan areas from 1993 to 1995. We hypothesized that the maternal country of origin would have a greater effect on birthweight than would the residential environment in which immigrants currently resided in urban Ontario.

Objectives. We compared the influence of the residential environment and maternal country of origin on birthweight and low birthweight of infants born to recent immigrants to urban Ontario.

Methods. We linked delivery records (1993–2000) to an immigration database (1993–1995) and small-area census data (1996). The data were analyzed with cross-classified random-effects models and standard multilevel methods. Higher-level predictors included 4 independent measures of neighborhood context constructed by factor analysis and maternal world regions of origin.

Results. Births (N=22 189) were distributed across 1396 census tracts and 155 countries of origin. The associations between neighborhood indices and birthweight disappeared after we controlled for the maternal country of origin in a cross-classified multilevel model. Significant associations between world regions and birthweight and low birthweight persisted after we controlled for neighborhood context and individual characteristics.

Conclusions. The residential environment has little, if any, influence on birthweight among recent immigrants to Ontario. Country of origin appears to be a much more important factor in low birthweight among children of recent immigrants than current neighborhood. Findings of neighborhood influences among recent immigrants should be interpreted with caution. (*Am J Public Health*. 2009;99:285–293. doi:10.2105/AJPH.2007.127498)

METHODS

Data

Birth and maternal obstetric records (with identifying information removed) from all Ontario hospitals were extracted from the hospital discharge abstracts compiled by the Canadian Institute for Health Information (1993–2000). The data were internally merged to combine maternal and newborn records by an algorithm described elsewhere,²⁸ resulting in a 95% valid match of the newborn records to a mother. Encrypted health care numbers of the Ontario Health Insurance Plan, which provides universal access to nearly all physician and hospital services (except for asylum seekers and before 3 months' residence), were used to link birth data with the Landed Immigrant Data System (1993–1995), compiled by Citizenship and Immigration Canada. This database included scrambled Ontario health care

numbers of 87% of the immigrants arriving in 1993 to 1995 whose intended destination was Ontario; it also contained sociodemographic information and characteristics related to the immigration process. These data were finally merged with small-area data from the 1996 Canadian census. We selected a group of women immigrating to Ontario's census metropolitan areas from January 1, 1993, to March 31, 1995, who had at least 1 live singleton weighing more than 500 g and less than 6000 g (N=38 121).

We restricted the study population to infants born to mothers who were recent immigrants, defined as residents of the country for less than 5 full years.^{29,30} We slightly modified this definition by shifting the 5-year observation period to begin after the 40th week of the mothers' arrival, to ensure that all mothers had been exposed to neighborhoods during their entire pregnancy (n=29 625). We retained only the first Canadian singleton born alive to each

woman within the 5-year period ($n=22\,516$). We excluded births to mothers younger than 15 years and older than 55 years ($n=5$), immigrants classified as “other” (i.e., not classified as economic, family, or refugee) ($n=62$), immigrants from countries that could not be classified according to their socioeconomic conditions ($n=180$), and records with missing information on place of residence ($n=80$). The study population used for analyses consisted of 22 189 live singleton infants born to women who immigrated to the Ontario census metropolitan areas from January 1993 to March 1995.

Mothers in the study came from 155 countries and were distributed across 1396 census tracts in all 10 of the 1996 Ontario census metropolitan areas.³¹ Census tracts (our neighborhoods) were relatively stable urban neighborhoods with a typical population of 2500 to 8000 and were relatively homogeneous in population characteristics and living conditions.

Measures

Birthweight (measured in grams) was modeled as a continuous response variable. Use of birthweight as a continuous outcome has several advantages. Birthweight provides directly interpretable effect estimates (differences expressed in grams) and greater statistical power than do categorical outcomes. Nonetheless, we also modeled low birthweight as a binary outcome (i.e., proportion of births weighing <2500 g) because of its clinical and policy relevance.

Table 1 presents the predictors at each level of the hierarchical structure of the data. To obtain groups of countries of origin that were as homogeneous as possible in their socioeconomic conditions, we considered world region and national income level. We derived both variables by the World Bank Atlas method with data from the World Bank 2000 classification of world economies,³² in which countries were classified according to their gross national income per capita. We modified the World Bank subregion classification by separating the United States from the remaining countries of the Americas. We used the group with the highest mean birthweight (eastern Europe–central Asia) as the referent.

We used more than 1 indicator of neighborhood context because neighborhood stressors and poor health were shown in

several studies to be linked.^{10,33–36} To capture the complexity of the neighborhood environment, we obtained 4 independent measures by performing factor analysis of census variables; this had the added benefit of avoiding problems of multicollinearity, because the principal components were not correlated. The neighborhood indices were material deprivation (Cronbach $\alpha=0.88$), residential instability (Cronbach $\alpha=0.93$), dependency (Cronbach $\alpha=0.72$), and ethnic diversity (Cronbach $\alpha=0.93$). All 4 indices were expressed as standardized continuous scores for modeling purposes. We collapsed them into tertiles for descriptive purposes in Table 1. Details of how these measures were constructed and their statistical properties are available elsewhere.³⁷

At the individual level we considered established predictors of birthweight available in our data, along with some circumstances of the immigration process that may have operated as potential confounders. We considered infant gender (male as referent), maternal age (15–19, 20–24, 25–29, 30–34 [referent], and 35–55 years), maternal education (0–9 years, 10–12 years, some postsecondary without a university diploma, and university diploma [referent]), and marital status (married or cohabiting [referent] and single, widowed, or separated). Gestational age in weeks was not available in the discharge records for the study period. We approximated gestational age by using gestational age groups (<28 , 28–36, 37–41 [referent], and ≥ 42 weeks) derived from the *International Classification of Diseases, Injuries and Causes of Death, Ninth Revision, Clinical Modification*.³⁸

Circumstances of immigration that have been linked to birth outcomes and may vary by country of origin included immigrant class (economic class, family class, and refugee status [referent])^{39,40} and knowledge of any official Canadian language (English or French; yes as referent).^{41,42} We assessed the amount of exposure to a Canadian setting by length of residence in Canada after the beginning of the 5-year observation period.^{43–46}

Statistical Analyses

Commonly used multilevel models cannot be used when the data do not present a purely nested structure. Immigrant mothers living in a particular neighborhood may have

come from several different countries, and mothers coming from a particular country may settle in different neighborhoods. Therefore, our data structure presented a cross-classification of countries and neighborhoods. Raudenbush and Bryk developed an extension of the multilevel model to analyze such data, known as the cross-classified random-effects model.^{47,48} (Technical details are available as a supplement to the online version of this article at <http://www.ajph.org>.) According to guidelines derived from simulation studies, the number of units at each level of our data structure was sufficient to obtain unbiased and precise regression coefficients, variance components, and standard errors.^{49,50}

Before we developed the cross-classified model, we conducted preliminary analyses focusing on 1 level at a time⁵¹ to assess whether there was significant variation at each level separately. We first used the usual 2-level random-intercept model, with births as level-1 units and with neighborhoods as level-2 units. In a second model, countries were the level-2 units. We found statistically significant variance for each of these models, so we used the cross-classified model to assess whether the variations in the outcome at each level were independent (in which case we used the cross-classified random-effects model for any further modeling) or were associated (if one factor was confounded by the other, rendering a variance nonsignificant, further modeling was reduced to the usual 2-level model). Then we proceeded to sequentially fit models adjusted for individual-level characteristics and group-level characteristics. We also tested for cross-level interactions to see whether the effect of neighborhood-level variables differed by country of origin, but none were statistically significant.

We used the MIXED procedure in SAS 9.1 (SAS Institute Inc, Cary, NC) to fit models, with the continuous measure of birthweight, and we modeled low birthweight with PROC GLIMMIX. Variance components estimates are reported with their standard errors and *P* values. The proportion of variance explained at each level was calculated with the intraclass correlation coefficient.^{47,50} We tested for significant variances in low birthweight with the Wald test.⁵⁰ Fixed effects in birthweight are reported as differences in mean birthweight expressed in grams; fixed effects in low

TABLE 1—Demographic Characteristics and Mean Birthweight and Low Birthweight Among Infants Born to Mothers Who Recently Immigrated to Urban Ontario: 1993–2000

	Countries, No. (%)	Census Tracts, No. (%)	Births, No. (%)	Birthweight, Mean (95% CI)	<i>P</i>	Low Birthweight, % (95% CI)	<i>P</i>
Total	155 (100)	1 396 (100)	22 189 (100)	3 288 (3 281, 3 295)		5.7 (5.4, 6.0)	
Country-level characteristics							
World regions					<.001 ^a		<.001 ^b
Eastern Europe/Central Asia	25 (16.1)	730 (52.3)	2 188 (9.9)	3 497 (3 475, 3 520)		2.9 (2.2, 3.6)	
Rest of Europe	22 (14.2)	589 (42.2)	1 022 (4.6)	3 421 (3 390, 3 453)		3.8 (2.7, 5.0)	
United States	1 (0.6)	319 (22.9)	411 (1.8)	3 463 (3 413, 3 513)		2.4 (0.9, 3.9)	
Latin America/Caribbean	32 (20.6)	829 (59.4)	3 467 (15.6)	3 265 (3 245, 3 285)		7.4 (6.5, 8.3)	
East Asia/Pacific	18 (11.6)	995 (71.3)	5 880 (26.5)	3 237 (3 225, 3 250)		5.4 (4.8, 5.9)	
South Asia	6 (3.9)	793 (56.8)	5 960 (26.9)	3 207 (3 194, 3 220)		7.0 (6.3, 7.6)	
Middle East	12 (7.7)	516 (37.0)	1 285 (5.8)	3 359 (3 332, 3 385)		3.7 (2.7, 4.8)	
North Africa	7 (4.5)	160 (11.5)	202 (0.9)	3 435 (3 364, 3 505)		3.5 (0.9, 6.0)	
East and South Africa	19 (12.3)	466 (33.4)	1 328 (6.0)	3 367 (3 336, 3 397)		4.8 (3.8, 6.0)	
West Africa	13 (8.4)	202 (14.5)	446 (2.0)	3 220 (3 158, 3 282)		9.2 (6.5, 11.9)	
Country of origin income level					<.001 ^c		<.001 ^d
Low	47 (30.3)	978 (70.1)	6 691 (30.2)	3 234 (3 221, 3 246)		6.4 (5.8, 7.0)	
Lower middle	43 (27.7)	1 146 (82.1)	10 308 (46.5)	3 293 (3 283, 3 304)		5.9 (5.4, 6.4)	
Upper middle	31 (20.0)	874 (62.6)	2 614 (11.8)	3 348 (3 327, 3 369)		4.6 (3.8, 5.4)	
High (non-OECD countries)	10 (6.5)	361 (25.9)	1 153 (5.2)	3 256 (3 229, 3 283)		4.5 (3.3, 5.7)	
High (OECD countries)	24 (15.5)	778 (55.7)	1 423 (6.4)	3 418 (3 392, 3 445)		3.4 (2.4, 4.3)	
Neighborhood-level characteristics							
Material deprivation, tertiles					.003 ^c		<.001 ^d
1 (Lowest)	140 (90.3)	740 (53.0)	7 336 (33.1)	3 296 (3 284, 3 308)		5.1 (4.6, 5.6)	
2	142 (91.6)	401 (28.7)	7 413 (33.4)	3 298 (3 286, 3 311)		5.6 (5.1, 6.1)	
3 (Highest)	126 (81.3)	255 (18.3)	7 440 (33.5)	3 270 (3 257, 3 282)		6.4 (5.8, 6.9)	
Residential instability, tertiles					<.001 ^c		.586 ^d
1 (Lowest)	136 (87.7)	610 (43.7)	7 387 (33.3)	3 268 (3 257, 3 280)		5.6 (5.1, 6.1)	
2	139 (89.7)	430 (30.8)	7 358 (33.2)	3 294 (3 281, 3 306)		6.0 (5.5, 6.6)	
3 (Highest)	142 (91.6)	356 (25.5)	7 444 (33.5)	3 302 (3 289, 3 314)		5.4 (4.9, 5.9)	
Dependency, tertiles					.038 ^c		.914 ^d
1 (Lowest)	144 (92.9)	464 (33.3)	7 382 (33.3)	3 305 (3 293, 3 318)		5.5 (5.0, 6.1)	
2	137 (88.4)	401 (28.7)	7 373 (33.2)	3 271 (3 259, 3 284)		5.9 (5.3, 6.4)	
3 (Highest)	135 (87.1)	531 (38.0)	7 434 (33.5)	3 287 (3 275, 3 299)		5.6 (5.1, 6.1)	
Ethnic diversity, tertiles					<.001 ^c		.027 ^d
1 (Lowest)	143 (92.3)	864 (61.9)	7 367 (33.2)	3 316 (3 304, 3 328)		5.1 (4.6, 5.6)	
2	137 (88.4)	336 (24.1)	7 405 (33.4)	3 280 (3 267, 3 292)		6.0 (5.4, 6.5)	
3 (Highest)	131 (84.5)	196 (14.0)	7 417 (33.4)	3 268 (3 256, 3 280)		5.9 (5.4, 6.5)	
Individual-level characteristics							
Infant gender					<.001 ^a		.04 ^b
Boy			11 357 (51.1)	3 337 (3 327, 3 347)		5.4 (4.9, 5.8)	
Girl			10 832 (49.9)	3 236 (3 227, 3 246)		6.0 (5.5, 6.4)	
Gestational age group, wk					<.001 ^c		<.001 ^d
<28			98 (0.4)	842 (779, 906)		99.0 (99.0, 100.0)	
28–37			1 016 (4.6)	2 353 (2 319, 2 386)		62.5 (59.5, 65.5)	
38–41			20 949 (94.4)	3 344 (3 337, 3 350)		2.5 (2.3, 2.7)	
≥42			126 (0.6)	3 494 (3 407, 3 581)		0.8 (0.0, 4.3)	

Continued

TABLE 1—Continued

Maternal age, y					
15–19	461 (2.1)	3 188 (3 139, 3 237)	<.001 ^a	7.4 (5.0, 9.8)	.002 ^b
20–24	3 770 (17.0)	3 221 (3 205, 3 237)		6.4 (5.6, 7.2)	
25–29	7 266 (32.7)	3 289 (3 277, 3 301)		5.1 (4.6, 5.6)	
30–34	6 903 (31.1)	3 323 (3 310, 3 336)		5.3 (4.8, 5.8)	
35–54	3 789 (17.1)	3 301 (3 283, 3 320)		6.4 (5.7, 7.2)	
Maternal education			<.001 ^c		<.001 ^d
≤9 y	4 100 (18.5)	3 259 (3 243, 3 275)		6.3 (5.6, 7.1)	
10–12 y	8 339 (37.6)	3 264 (3 253, 3 276)		6.2 (5.7, 6.7)	
Postsecondary without a university diploma	6 152 (27.7)	3 319 (3 306, 3 332)		5.0 (4.5, 5.6)	
University diploma	3 598 (16.2)	3 323 (3 305, 3 340)		4.8 (4.1, 5.5)	
Marital status			<.001 ^a		<.001 ^b
Married/common law	13 764 (62.0)	3 312 (3 303, 3 321)		5.3 (4.9, 5.7)	
Single/divorced/separated	8 425 (38.0)	3 248 (3 237, 3 260)		6.3 (5.8, 6.8)	
Immigrant class			<.001 ^a		.09 ^b
Economic class	4 965 (22.4)	3 325 (3 310, 3 341)		5.6 (5.0, 6.2)	
Family class	14 137 (63.7)	3 257 (3 248, 3 265)		5.9 (5.5, 6.3)	
Refugees	3 087 (13.9)	3 371 (3 352, 3 391)		4.9 (4.1, 5.6)	
Knowledge of English or French			<.001 ^a		0.29 ^b
Yes	13 186 (59.4)	3 302 (3 293, 3 312)		5.8 (5.4, 6.2)	
No	9 003 (40.4)	3 267 (3 257, 3 278)		5.5 (5.0, 5.9)	
Length of residence, y			.019 ^c		.148 ^d
0	7 734 (34.9)	3 278 (3 266, 3 290)		5.4 (4.9, 5.9)	
1	5 028 (22.7)	3 282 (3 267, 3 297)		6.0 (5.3, 6.6)	
2	3 949 (17.8)	3 306 (3 289, 3 322)		5.1 (4.5, 5.8)	
3	3 016 (13.6)	3 285 (3 266, 3 306)		6.2 (5.4, 7.1)	
4	2 462 (11.1)	3 304 (3 282, 3 326)		6.1 (5.2, 7.0)	

Note. CI = confidence interval; OECD = Organisation for Economic Co-operation and Development.

^aAnalysis of variance used for comparison of means.

^b χ^2 test for comparison of proportions.

^cLinear trend across means.

^dCochran-Armitage test for trend for proportions.

birthweight are reported as adjusted odds ratios with 95% confidence intervals.

RESULTS

Table 1 presents the distribution of the characteristics of the population at the country, neighborhood, and individual levels. Immigrants from Asian countries had the largest share of births, followed by women from Latin American and Caribbean countries. We found significant differences in birthweight by world region and income level of the mother's country of origin. Differences in birthweight by neighborhood tertiles were smaller but statistically significant. Material deprivation was the only neighborhood characteristic for which we detected a gradient in low

birthweight in the expected direction: higher material deprivation was associated with lower birthweight.

At the individual level, we found higher birthweight in boys and in infants with greater gestational age. Maternal characteristics associated with higher birthweight included increasing age up to 30 to 34 years; having a university diploma, being married, being a refugee, and having knowledge of English or French; and having spent more time in Canada. The direction of the associations differed for low birthweight, except with infant gender, gestational age, and maternal education.

Table 2 shows the results of the multilevel models assessing neighborhood effects on birthweight, before (models 1 and 2) and after (models 3 and 4) including the country-of-

origin context. Models 1 and 2 represented the usual 2-level model with births nested within neighborhoods. Model 1 included the 4 neighborhood factors, which were significant, with the exception of the material deprivation score. Together, the 4 neighborhood factors explained 42% of the variability observed across neighborhoods. When individual characteristics were included in model 2, significant variability between neighborhoods remained.

The cross-classified models (models 3 and 4) differed from models 1 and 2 because they included an additional random-variance component at the country level. The addition of the country-level context in model 3 rendered both the neighborhood-level variance and all the neighborhood indices nonsignificant. The country-level variance, however, remained

TABLE 2—Fixed Effects of Neighborhood Indices on Birthweight and Random Effects Among Recent Immigrants to Urban Ontario: 1993–2000

	Two-Level Models		Cross-Classified Models	
	Model 1 ^a	Model 2 ^b	Model 3 ^a	Model 4 ^b
Fixed effects, b (95% CI)				
Intercept	3321 (3311, 3332)	3531 (3505, 3557)	3364 (3337, 3390)	3523 (3489, 3558)
Material deprivation	-10 (-21, 1)	1 (-8, 10)	-8 (-18, 2)	-2 (-11, 7)
Residential instability	20 (10, 29)	12 (3, 20)	0 (-9, 9)	-1 (-9, 7)
Dependency	-14 (-24, -3)	-9 (-18, 0)	-8 (-18, 2)	-7 (-15, 2)
Ethnic diversity	-25 (-34, -17)	-23 (-30, -16)	-4 (-12, 4)	-4 (-10, 3)
Random effects, variance (SE)				
Variance at the neighborhood level (τ_{b00}^2):	2022** (571)	1320* (431)	215 (399)	255 (304)
Variance at the country level (τ_{c00}^2):	13737** (2596)	10400** (1995)
Residual variance (σ^2):	283014** (2724)	208223** (2007)	272954** (2626)	201375** (1939)

Note. CI = confidence interval. Birthweight measured in grams. Two-level models included random neighborhood variances. Cross-classified models included random neighborhood and country of origin variances. Models 1 and 2 did not include random intercepts at the country level.

^aModel with neighborhood predictors.

^bAdjusted for individual characteristics: infant gender, maternal age groups, gestational age groups, maternal education groups, immigrant class, marital status, knowledge of English or French, and length of residence in Canada.

* $P < .01$; ** $P < .001$.

highly significant even after adjusting for individual characteristics in model 4. In this model, the partition of the variance indicated that 4.9% of the total variance in birthweight occurred at the country level and only 0.12% at the neighborhood level. Collapsing the neighborhood indices into tertiles did not improve the fit of the model (data not shown); therefore, we kept the continuous specification of the neighborhood indices. Models adjusted for individual characteristics showed higher infant mean birthweight because most reference categories were those associated with higher birthweight, such as an infant being male, being born within 38 and 41 weeks of gestation, and having a married mother with high maternal age and education.

To understand why the variability in birthweight at the neighborhood level disappeared after we controlled for country of origin, we tested the hypothesis that the pattern of settlement of recent immigrants was not random by cross-tabulating material deprivation tertiles of births with world regions. The χ^2 test was highly significant ($\chi^2_{(df=18)}=1052$; $P < .001$), indicating that newly arrived immigrant women from particular regions of the world did not settle randomly across urban neighborhoods. Women coming from poorer regions of the world (e.g., African and Latin American countries and, to a lesser extent, South Asia)

settled in neighborhoods characterized by higher material deprivation. Women coming from wealthier regions (e.g., United States, rest of Europe, and, to a lesser extent, East Asia and Pacific) tended to concentrate in less deprived neighborhoods. The neighborhood-level variance and predictors were no longer significant in the cross-classified models; we then reduced the model to a 2-level model, with births nested within countries of origin. Table 3 shows the results of the 2-level model, including world regions as the only country-level predictor (model 5), because income levels of the country of origin were no longer significant after we included world regions.

The intraclass correlation coefficient indicated that 46.7% of the variance at the country level was explained by grouping the countries into world regions. Significant differences in birthweight between world regions persisted after we controlled for individual characteristics in model 6, as did the unexplained variability at the country level. Most world regions had lower mean birthweights than did eastern Europe and central Asia, except the United States and North Africa, probably because of low statistical power: few immigrants in our study came from the latter 2 regions.

The results for low birthweight differed in the significance of the variance at the neighborhood level. Unlike with birthweight, there

was not significant variability in low birthweight in the 2-level model with births nested within neighborhoods ($\tau_{b0}^2=0.01$; SE=0.03; $P > .05$, 1 sided) or in the cross-classified model considering both the neighborhood- and country-level contexts. None of the neighborhood indices were significantly associated with low birthweight in either of these 2 models. We therefore dropped the neighborhood context and continued the modeling of low birthweight by considering the country context only.

Variability in low birthweight at the country level, by contrast, was significant in the 2-level model with births nested within countries and also in the cross-classified model ($\tau_{c00}^2=0.20$; SE=0.06; $P < .001$, 1 sided). It remained significant after we controlled for individual-level covariates ($\tau_{c0}^2=0.15$; SE=0.05; $P < .01$, 1 sided), although the variance was somewhat reduced. The full model (Table 4), including all individual characteristics and world regions, rendered the country-level variance nonsignificant ($\tau_{c0}^2=0.07$; SE=0.05; $P > .05$, 1 sided), implying that after countries were grouped into regions, there was no further variability to be explained at the country level. Fixed-effect estimates resembled the pattern found for birthweight. The risk of low birthweight varied considerably according to the region of origin of the immigrant mothers.

TABLE 3—Fixed Effects of World Regions on Birthweight Among Infants Born to Recent Immigrants to Urban Ontario: 1993–2000

World Region	Model 5, ^a b (95% CI)	Model 6, ^b b (95% CI)
Eastern Europe/Central Asia	0	0
Rest of Europe	-73 (-153, 7)	-76 (-143, -9)
United States	-42 (-229, 145)	-47 (-200, 105)
Latin America/Caribbean	-150 (-220, -80)	-133 (-192, -75)
East Asia/Pacific	-246 (-323, -169)	-238 (-302, -174)
South Asia	-281 (-377, -184)	-241 (-320, -162)
Middle East	-168 (-257, -79)	-157 (-230, -83)
North Africa	-83 (-207, 41)	-89 (-192, 15)
East and Southern Africa	-236 (-322, -151)	-206 (-278, -135)
West Africa	-226 (-350, -102)	-195 (-298, -91)

Note. CI = confidence interval. Birthweight measured in grams.

^aNot adjusted for individual characteristics.

^bAdjusted for individual characteristics: infant gender, maternal age groups, maternal education groups, gestational age groups, immigrant class, marital status, knowledge of English or French, and length of residence in Canada.

DISCUSSION

In a study population of women who recently immigrated to urban Ontario, we found that the neighborhood context had little, if any, effect on birthweight or low birthweight. Neighborhood influences on birthweight disappeared after we controlled for the mother's country of origin, suggesting that

self-selection of recent immigrants from various world regions into particular neighborhoods explains the observed associations between neighborhood characteristics and birthweight.

By contrast, we found important contextual effects from the maternal country of origin for both birthweight and low birthweight, after adjusting for individual characteristics. Compared with migrants from eastern Europe and central Asia, migrants from other world regions had worse outcomes, with the exception of those from North Africa, the United States, and the rest of Europe. Low rates of preterm birth (<37 completed weeks of gestation) and low birthweight have been documented among North African migrants to Belgium^{52–55} and France.⁵⁶ US immigrants to Ontario had lower rates of low birthweight in singleton births than did US-born non-Hispanic Whites in the United States in a comparable period,⁵⁷ suggesting that these US immigrants were healthier than were their nonimmigrant counterparts. These findings should be interpreted as related to the maternal country of origin rather than to maternal country of birth, which could be different for some women.

Strengths and Limitations

Among the strengths of this study was its nearly complete coverage of the target population. Selection bias was not an issue because almost all Ontario permanent residents were

insured by the provincial health plan. Unlike in many studies that rely on self-reported data, immigration status, country of origin, and other maternal characteristics were ascertained through a government computerized immigration database. Because notarized copies of the personal documentation of principal applicants and their family members were required by law, this database was highly accurate. The use of an appropriate statistical method that allowed simultaneous consideration of the role of 2 relevant contexts strengthened our conclusions.

This study had some limitations. Imperfect measurement of some individual control variables may have introduced some residual confounding. Maternal education and marital status were measured at arrival but could have changed for some women during the study period; however, the relatively short time from arrival to delivery made it improbable that substantial shifts in educational attainment were experienced by many women before delivering their first Canadian-born child. Information on parity was not available in hospital records for the study period. We minimized confounding for parity, however, by selecting only the first Canadian-born infant for each mother. We do not have reason to believe that parity would differ systematically according to the country of origin, with the possible exception of immigrants from China, because of its 1-child policy. Finally, we did not control for behavioral risk factors and maternal morbidity during pregnancy because they are considered to be mediators in the relationship between socioeconomic factors and birth outcomes.^{1,58,59}

Neighborhood context was assessed at the time of delivery, but some of the mothers may have been exposed to more than 1 neighborhood within the study period; the probability of this was higher among mothers who took longer to have their first Canadian-born infant. A lack of information about the residential trajectory of the mothers prevented us from assessing the extent of this bias. Residential mobility is a complex phenomenon that may be influenced by individual and neighborhood characteristics and class relations and may vary by ethnic group, nativity status, and length of residence.^{60–62} It is unlikely, however, that residential mobility introduced serious bias, because

TABLE 4—Adjusted Odds Ratios (AORs) of Effect of Country of Origin, by Region, on Low Birthweight Among Infants Born to Recent Immigrants to Urban Ontario: 1993–2000

Region	AOR (95% CI)
Eastern Europe/Central Asia (Ref)	1.00
Rest of Europe	1.59 (0.88, 2.86)
United States	0.87 (0.31, 2.43)
Latin America/Caribbean	2.15 (1.34, 3.45)
East Asia/Pacific	1.96 (1.21, 3.18)
South Asia	2.80 (1.67, 4.68)
Middle East	1.81 (1.02, 3.22)
North Africa	1.38 (0.49, 3.84)
East and Southern Africa	2.08 (1.17, 3.67)
West Africa	2.22 (1.01, 4.85)

Note. CI = confidence interval. OR adjusted for individual characteristics: infant gender, maternal age groups, maternal education groups, gestational age groups, immigrant class, marital status, knowledge of English or French, and length of residence in Canada.

our study population was restricted to recent immigrants. Moreover, a recent study did not find substantial differences between longitudinal and cross-sectional estimates of neighborhood effects on children's well-being,⁶¹ suggesting that most families moved between neighborhoods of the same socioeconomic type, which is consistent with the research of South et al. on interneighborhood socioeconomic mobility.⁶²

Our 4 independent indices of neighborhood context were based on census data that essentially reflected aggregated characteristics of the population, but we did not use measures derived from other data sources that might have provided information about other aspects of the residential milieu. In Canada, census tract boundaries have been found to correspond well to those of natural neighborhoods.⁶³ Several Canadian studies that used this geographic unit of analysis found significant area-level effects with a broad array of outcomes,^{37,64–67} including birth outcomes.^{68,69}

Conclusions

We did not expect higher birthweights among refugees than among nonrefugee immigrants, because refugees usually emigrate from high-stress environments, which could lead to adverse birth outcomes. The birthweight advantage of refugees was reduced in the adjusted models, but it remained significant, implying a role of unmeasured factors. Studies comparing obstetric outcomes of refugees and asylum seekers from Somalia and Kosovo–Albania with those of United Kingdom–born and US-born White women did not find significant differences,^{40,70,71} probably because of small sample sizes.

We also found that the trend for birthweight increased with length of residence, even after adjustment. Although the reasons for this finding in Ontario are not clear, previous research suggested that birth outcomes may either improve or deteriorate with length of residence among first-generation immigrants, depending on the migrant group or the receiving environment or a combination of both. For instance, the risk of preterm birth and low birthweight increased with length of residence among Mexican immigrants to the United States^{29,43} and among Asians and Pacific Islanders in Sweden but decreased among Finns⁴⁵; other migrant groups were unaffected.

The absence of significant neighborhood effects on birthweight among immigrants that we observed is not surprising given the inconsistent associations with measures of socioeconomic position found among diverse ethnic immigrant groups to the United States.^{18,19,57,72,73} The finding of important country-level effects is consistent with a literature reporting wide variability in pregnancy outcomes by world region, country, and ethnicity.^{23,72} Although our findings are consistent with a recent study in which the association between residential segregation and low birthweight disappeared after control for nativity among immigrant Black women to New York City,¹⁵ generalization to North American cities with little ethnic and nativity diversity may be limited.

Our findings are also consistent with 3-level studies that showed significant reductions in the amount of variability attributable to the neighborhood context after taking into account an additional context such as the family or household.^{74–76} Such evidence suggests that 2-level studies of neighborhood effects may overestimate the contribution of the residential environment if they disregard other contexts potentially relevant to the population and outcome under study. Interventions and policy recommendations at the neighborhood level should be cautious if they are based on studies that did not control for other meaningful contexts for the study population. We did not find evidence that neighborhoods matter for immigrants' offsprings' birthweight, but this cannot be generalized to other outcomes without further empirical research.

Our findings could help to direct prenatal and even preconception programming toward recently arrived women from higher-risk countries of origin. Although neighborhood may not have a major influence on low birthweight in urban Ontario, it can provide a vehicle to reach out to women who are at particular risk upon entry into Canada, through facilitating local access to culturally sensitive prenatal care and translation services. ■

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Contributors

M.L. Urquia designed the study, analyzed the data, and led the writing. J.W. Frank and R.H. Glazier supervised the study and revised the article. R. Moineddin participated in the data analyses. F.I. Matheson participated in the design. A.J. Gagnon helped with the literature review. All authors contributed to the writing of the article.

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